SB761
U7P2
#89-05

United States
Department of
Agriculture

Forest Service

**Pacific
Northwest
Region**

Forest Pest Management

R6-89-05

Black Stain Root Disease Incidence and Severity on the Medford District, Bureau of Land Management

SURVEY OF BLACK STAIN ROOT DISEASE INCIDENCE AND SEVERITY IN 10- TO 30-YEAR-OLD DOUGLAS-FIR PLANTATIONS ON THE MEDFORD DISTRICT, BUREAU OF LAND MANAGEMENT

Paul F. Hessburg, Donald J. Goheen, and Tommy F. Gregg

USDA Forest Service

Forest Pest Management

Pacific Northwest Region

and

Harv Koester,

Medford District

Bureau of Land Management

LIBRARY COPY
ROCKY MTN. FOREST & RANGE
EXPERIMENT STATION

SUMMARY

Incidence and severity of black stain root disease were evaluated in a two-stage sample of precommercial-aged Douglas-fir plantations on the Medford District, BLM. Black stain was widely distributed throughout the western half of the District. Nearly 19 percent of all the susceptible-aged Douglas-fir plantations were infested to some degree by black stain; mortality losses were extremely low. Twenty-four percent of the plantations had black stain on the Glendale Resource Area. Grants Pass and Jacksonville Resource Areas had black stain in approximately 17 percent and 16 percent of plantations, respectively. Butte Falls and Klamath Resource Areas had little or no black stain and should not be considered part of the area of highest black stain hazard.

Black stain was more often distributed in precommercially thinned than non-precommercially thinned plantations; the interaction was significant in both the extensive and intensive surveys. Black stain occurred with significantly greater frequency adjacent to roads or major skid trails than the main body of plantations. Roadside strips typically had more injured trees and a greater amount of recent soil disturbance than the main body of plantations.

On the Medford District, the incidence of black stain root disease is high, but damage severity is minimal and there is virtually no impact to precommercial stand management at the present time. Incidence and general distribution of black stain root disease appear to be highly associated with roads and major skid trails. Increasing damage severity appears to be highly associated with increasing site disturbance and tree injury. The conspicuous lack of severe damage on the Medford District is associated with a lack of extensive tractor-yarding and a lack of extensive precommercial thinning. In other closely related surveys, severe damage has consistently been associated with extensive tractor-yarding and precommercial thinning.

The challenge ahead for resource managers on the Medford District is to maintain damage severity at an acceptably low level using the tools of integrated pest management. Preventative and corrective management strategies are presented and discussed.

INTRODUCTION

Black stain root disease, caused by the fungus Leptographium wageneri (Kendrick) Wingfield[1/], is a lethal root disease of several western conifers. The black stain fungus kills host trees by colonizing water conducting tissues of roots, root collars, and lower stems. Fungal hyphae and host reaction compounds ultimately block movement of water to foliage. Severely infected trees exhibit wilting symptoms characteristic of vascular wilt diseases such as Dutch elm disease, caused by Ophiostoma ulmi, and oak wilt, caused by Ceratocystis fagacearum.

Black stain kills young trees within a year or two of infection; older infected trees decline more slowly (2 to 8 years) and are often predisposed to bark beetle infestation.

In the Pacific Northwest Region, Douglas-fir is the principal host. Other hosts are ponderosa pine, lodgepole pine, western hemlock, and mountain hemlock, but these are seldom damaged.

Recent research indicates that there are two distinct variants of L. wageneri in the Northwest, each has a specific host preference. One variety, var. pseudotsugae, attacks Douglas-fir; the other, var. ponderosum, attacks hard pines and hemlocks. While limited crossover has been shown experimentally, it is seldom detected in nature and occurs only under exceptional conditions. For purposes of resource management, these variants can be considered host specific.

In southwest Oregon, black stain affects only Douglas-fir (Pseudotsuga menziesii var. menziesii) and most infection centers are found in 10- to 30-year-old plantations. Crown symptoms of trees affected by black stain root disease are very similar to those associated with other root diseases such as laminated root rot and Armillaria root disease. Trees infected by the black stain fungus usually exhibit symptoms of gradual declining health before succumbing (Figs. 1, 2, 3, 4). In early stages of decline, terminal growth is reduced and older needles become chlorotic. As the disease progresses, older needles are prematurely shed, new needles are somewhat stunted and yellow, and reduced internodal growth is evident on lateral branches. In advanced stages, new growth is compact, chlorotic, with a tufted appearance, and tree crowns are sparsely foliate, often bearing a distress cone crop.

1/ Other names applied to the fungus that causes black stain root disease are Ophiostoma wageneri (Goheen and Cobb) Harrington, Ceratocystis wageneri (Goheen and Cobb), and Verticicladiella wageneri Kendrick. Ophiostoma wageneri is currently the accepted name for the teleomorph (sexual stage) of the fungus, however, ascocarps (perithecia) are only known from ponderosa pine. Leptographium wageneri describes the anamorph (asexual stage) in Douglas-fir.

Very small trees, or those affected by other significant stress factors, may succumb quickly without exhibiting gradual decline symptoms; foliage may change from green to yellow or reddish-brown. Some infected trees exhibit basal resinosis (Fig. 5).

Black stain root disease can be distinguished from other root diseases by the distinctive chocolate-brown to purple-black stain in the sapwood of roots and lower stems of infected trees (Fig. 6). When observed in cross-section, the black stain appears in arcs roughly concentric with the growth rings (Fig. 7). In contrast, blue stains that are sometimes confused with black stain, are often a lighter blue-gray to black. They are wedge-shaped in cross-section, or they discolor the entire sapwood radius.

Black stain root disease affects groups of trees in distinct infection centers (Fig. 8). Typical infection centers have trees in various stages of decline near the perimeter and dead trees in the interior nearer the origin of initial infection. Infection centers usually occur in well-stocked stands where a preferred host predominates or occurs in unmixed clumps. Groups of closely associated disease centers are frequently encountered (Fig. 9). Black stain centers are most prevalent in areas where substantial tree damage or site disturbance has occurred, especially along roads and skid trails (figs. 10, 11, 12), in areas having a history of tractor logging and resultant soil compaction, and in areas that have been precommercially thinned. Centers are usually small (1/3 acre or less), but may reach several acres in size.

Long-distance spread of the black stain fungus involves insect vectors (Fig. 13). The root-feeding bark beetle, Hylastes nigrinus (Coleoptera: Scolytidae), is a primary vector of the fungus in Douglas-fir. Two weevils, Steremnius carinatus and Pissodes fasciatus (Coleoptera: Curculionidae), have also been implicated as vectors in Douglas-fir, but their involvement in local and long distance-spread of the pathogen is yet poorly understood.

Vector insects commonly breed in roots of recently dead, dying, or stressed host trees, including those infected by L. wageneri. Vectors also breed in Douglas-fir precommercial thinning stumps, which are susceptible to infection by L. wageneri for up to 7 months after stems have been severed. The appearance of new black stain disease centers in areas of disturbance reflects vector insect preference for stressed or injured trees.

L. wageneri sporulates readily inside insect galleries in infected roots and root collars. Stalked, microscopic fruiting bodies form on gallery walls, each bearing a sticky spore droplet which protrudes into gallery lumens. These sticky spore droplets are well suited to insect dispersal. During emergence, some young adult beetles are contaminated with spores as they brush against spore droplets in galleries or pupal

chambers. Contaminated beetles fly or walk from brood trees, burrow through the duff and soil, visit roots of healthy, recently dead or dying trees, and deposit spores on root sapwood exposed during feeding. Wounds that expose sapwood xylem are required for infection since L. wageneri hyphae are unable to penetrate live bark and cambial tissues. Once established, the black stain fungus rapidly colonizes root and stem sapwood xylem reducing, water uptake and the axial ascent of xylem sap. Infected trees usually die when soil moisture is depleted, and/or important water conducting tissue is blocked by hyphae and host reaction compounds and daily evapotranspiration exceeds water uptake.

Once a new center is established, spread of the infection from tree to tree occurs through root grafts that join healthy and diseased trees, and between intimately associated roots, via limited growth (< 15 cm) of the pathogen through soil (Fig. 14). Small rootlets (< 5 mm dia.) serve as conduits of infection where roots are not grafted. New infections that result from tree to tree spread, occur regardless of tree vigor. The spread rate of black stain root disease is 3 to 5 times greater than that of other root diseases. Infection centers in Douglas-fir enlarge on the margin at an average annual rate of 1 to 1.5 meters per year, though spread at a rate of 3 to 6 meters per year has been documented. Leptographium wageneri is relatively nonpersistent in infested root systems, remaining active usually no more than 1 year after its host dies.

The importance of black stain root disease as a threat to resource management has steadily increased in the Pacific Northwest in the 1980's. The distribution of black stain in young Douglas-fir stands in southwest Oregon has increased dramatically over the last 10 years, and we anticipate that the increase will continue as more stands are brought under management. Since increasing incidence of black stain is favored by stand and site conditions that result from intensive forest management practices, and disease spread locally and over long distances is rapid, we anticipate that incidence of this disease will continue to increase in southwest Oregon in the coming decade, as will the threat to resource management.

Black stain has been observed with increasing frequency over much of the western half of the Medford District since about 1980. This evaluation was done to:

1) Determine the actual incidence and severity of black stain root disease in a representative sample of 10- to 30-year-old Douglas-fir plantations on the Medford District, and

2) compare disease occurrence and damage in a sample of precommercially thinned and unthinned plantations where the previous stand was either tractor- or cable-yarded.

METHODS

A list of all plantations established between 1956 and 1976, on each of the five Resource Areas, was obtained from the Medford District forest inventory database. Table 1 shows the breakdown of plantations by Resource Area. From this listing, a sample universe was developed. Of the 1,979 plantations listed in the original database query, 737 were regenerated to less than 50 percent Douglas-fir by stocking. They were eliminated from further consideration, leaving 1,242 predominantly Douglas-fir plantations in the sample universe. Five hundred (500) plantations were then selected at random, with replacement, and these became the sample frame. The number selected in each Resource Area was weighted according to occurrence percent; i.e., (Douglas-fir plantations in a Resource Area) / (total number of Douglas-fir plantations on the District) X 100. Table 2 shows the breakdown of Douglas-fir plantations surveyed by Resource Area, and the survey and occurrence percentages represented by each Resource Area.

Extensive Survey. A two-stage sampling procedure was used to evaluate black stain incidence and severity in Douglas-fir plantations. The first stage was an extensive survey aimed at determining disease incidence and establishing its general distribution in each Resource Area. To accomplish this, two-chain wide roadside strips were carefully examined along both sides of every road and drivable skid trail running through or bordering each of the 500 plantations. A roadside traverse was used because of the extremely high correlation between incidence of black stain and proximity to roads noted by pest management specialists, resource managers, and published in the forest disease research literature.

Plantations in the extensive survey were visited between June and September 1986 and 1987. Data collected for each plantation included:

1) site number, legal description, unit number
2) plantation age and acres
3) presence/absence of black stain root disease, Armillaria root disease, or laminated root rot
4) aspect
5) yarding history (tractor vs. cable)
6) precommercial thinning history (thinned or unthinned)
7) regeneration method (natural or planted)
8) presence/absence of animal or mechanical damage

All dead and apparently declining trees were inspected, and pathogens infecting them were identified and noted. Once black stain was identified in a single tree, the extensive survey of that plantation was complete. When black stain was not encountered, survey of the roadside strips continued to completion.

Intensive Survey. The second stage of sampling was an intensive survey of a random selection (with replacement) of plantations surveyed in the first stage of sampling; 80 plantations were surveyed, 10 plantations

in each of 8 sample categories. Table 3 shows the array of sample categories in the intensive subsample. The objectives of the second stage of sampling were to:

1) assess damage severity in plantations with demonstrated occurrence of black stain,
2) to conduct a controlled observation of black stain incidence relative to roadside or skid trail proximity,
3) to relate observed damage severity to specific disturbances (thinning and yarding).

These 80 plantations were visited between June and September 1987, and two series of fixed-area plots were established in each. One series of plots was established at two-chain intervals centered 25 feet into the plantations on both sides of all roads and skid trails. A second series of plots was located at two-chain intervals along four equally spaced transects that ran completely across each plantation, roughly perpendicular to the longest section of road. In both series, plots were 1/100-acre fixed-radius plots (radius = 11.8 feet), and within each, all trees were tallied and examined. Recorded data included:

1) sample category
2) transect number and location (roadside vs. main body)
3) fixed plot number, tree species, tree condition
4) presence/absence of black stain root disease, Armillaria root disease, or laminated root rot
5) crop tree designation (crop, excess, or ingrowth)
6) regeneration history (natural or planted)
7) presence/absence of animal or mechanical damage

Thus, overall stocking, as well as severity of infection and mortality caused by black stain and other root diseases, was estimated for both the roadside strips and the main body of each plantation.

Statistical Analyses. Statistical comparisons of the incidence of black stain root disease in each sample category were done using Pearson's Chi-square analysis and contingency tables. Differences in damage severity among sample categories would be compared by analysis of variance (ANOVA, $P \leq 0.05$), and significant differences between categories would be compared using Duncan's New Corrected Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Incidence of Black Stain Root Disease - Extensive Survey Results.

Black stain was detected in 18.6 percent of the 500 plantations evaluated in the first stage of sampling, and was found much more frequently than the other diseases of Douglas-fir. Armillaria root disease, caused by Armillaria ostoyae (obscura), was found in roadside strips in 1.2 percent of the plantations; laminated root rot, caused by Phellinus weirii, was found in roadside strips in 7 percent of the plantations. Black stain was widely distributed but was most common to

the western half of the District (Table 4, figs. 15, 16, 17, 18, and 19). Incidence was 24.2 percent on the Glendale Resource Area, 16.6 percent on the Grants Pass Resource Area, and 15.8 percent on the Jacksonville Resource Area. Butte Falls and Klamath Resource Areas had little or no black stain at 4.2 and 0.0 percent incidence, respectively.

Table 4 shows the breakdown of black stain incidence (percentage of plantations) by thinning history, yarding history, and combinations of thinning and yarding history for each Resource Area and for the District. The results of Chi-square tests of independence are also given. Chi-square analyses indicated that the Glendale Resource Area had significantly more black stain than would be expected were there no effect of location, and the Butte Falls and Klamath Resource Areas had significantly less ($P = 0.05$), the latter indicating the likelihood of significant black stain root disease occurrence and damage at any time.

Contingency analysis of incidence by precommercial thinning and yarding history, and combinations thereof, indicated the following: on the Glendale Resource Area, precommercial thinning interacted significantly with increased incidence, while a lack of precommercial thinning interacted significantly with reduced incidence of black stain ($P = 0.01$). Also significant were interactions between black stain incidence and plantations where the previous timber stand had been cable-yarded and precommercially thinned; such plantations had significantly more root disease. Those that had been cable-yarded and had not been thinned had significantly less ($P = 0.005$).

On the Grants Pass Resource Area, tractor-yarded stands were more often found with black stain than cable-yarded stands, as were tractor-yarded stands that had or had not been precommercially thinned, but differences were not significant ($P = 0.17$ and 0.19, respectively).

At Jacksonville, precommercially thinned plantations that had been both tractor- and cable-yarded were more often found with black stain. Plantations that had not been precommercially thinned had significantly less black stain ($P = 0.07$).

Butte Falls and Klamath Resource Areas had significantly lower incidence of black stain overall ($P = 0.05$), and there were no significant interactions with either thinning or yarding history.

Chi-square tests of independence of black stain incidence with thinning and yarding histories for the entire Medford District (Resource Area data compressed), revealed several significant interactions. Precommercially thinned plantations were more likely to have black stain root disease ($P = 0.05$), whether they had been previously cable-yarded ($P = 0.04$), or tractor- and cable-yarded ($P = 0.1$). Plantations that were previously cable-, or both tractor- and cable-yarded, and had not been precommercially thinned, were less likely to have black stain ($P = 0.04$, and $P = 0.01$, respectively).

Tests of independence for Resource Areas, thinning histories, and yarding histories, revealed several significant interactions. More plantations were precommercially thinned on the Glendale Resource Area than expected, fewer plantations were thinned on the Grants Pass Resource Area ($P = 0.09$). An enumeration of plantations by Resource Area and yarding history revealed that, on average, 62 percent of all plantations had a history of cable yarding, 15 percent were cable-yarded with some tractor-yarding, and 23 percent were tractor-yarded only. On the Klamath and Butte Falls Resource Areas, more plantations than expected had a history of tractor-yarding, and fewer had a history of cable-yarding. Fewer plantations than expected had a history of tractor-yarding on the Grants Pass and Jacksonville Resource Areas, and more plantations than expected had a history of both tractor- and cable-yarding on Jacksonville ($P < 0.0001$).

Black Stain Root Disease Severity - Intensive Survey Results.

Although black stain is widely distributed throughout the western-half of the Medford District, damage severity is extremely light (Table 5). Among the 80 intensively sampled plantations where black stain was detected (Fig. 20), there was little variation in damage severity. A breakdown by loss category follows:

1) 93 percent of the infested stands had trace amounts of infection (0.1 percent or less of the crop tree Douglas-fir affected);
2) 3 percent were lightly diseased (between 0.1 and 2 percent of the crop tree Douglas-fir affected);
3) 3 percent were moderately diseased (between 2 and 5 percent of the crop tree Douglas-fir affected); and
4) 1 percent were severely diseased (more than 5 percent of the crop tree Douglas-fir affected).

Where black stain occurred, it usually involved trees in discrete pockets rather than scattered mortality, and it most often occurred adjacent to major roads or skid trails. By design, half of the 80 plantations in the intensive survey had black stain already identified in trees in the roadside strip during the first (extensive) stage of sampling. When intensively resurveyed, only 13 percent, or 5 of 40 plantations had enough black stain in the roadside portions to be detected in the second stage of sample, and of these 5, only 2 plantations had black stain in the main body of the plantation not associated with roads or major skid trails.

The overall incidence of black stain on the Medford District is comparable to that of other forest ownerships in the vicinity and throughout the area of known high black stain hazard (southern Oregon and northern California west of the Cascade Mountain Range). Butte Falls and Klamath Resource Areas are rather atypical of high hazard areas, and as such, should not be considered in the same light as the Glendale, Grants Pass, and Jacksonville Resource Areas.

Mortality losses were considerably less than in other localities in the Pacific Northwest where past surveys have been done. Several factors may be responsible for the observed limited damage severity:

1) 62 percent of all 10- to 30-year-old Douglas-fir plantations had a history of previous cable-yarding, minimizing soil compaction and disruptions to soil drainage for the subsequent generation of trees. An additional 15 percent of plantations were mostly cable-yarded with some tractor-yarding. Only 23 percent of the plantations had experienced the rather extreme disturbance of tractor-yarding only. Past surveys on the Siskiyou National Forest, Tioga Resource Area of the Coos Bay District, and on Weyerhaeuser Company lands have shown that, in areas that were predominantly tractor-yarded, black stain incidence and damage severity were usually quite extreme. Both higher roading densities associated with ground-based logging systems, and the soil disturbance of tractor-yarding were proposed as the principal contributing factors. On the Medford District, it is likely that roading densities are lower and site disturbance effects less than adjacent ownerships where black stain damage severity is quite high.

2) 74 percent of all plantations have not been precommercially thinned, minimizing plantation attractiveness to potential insect vectors of black stain root disease. Most plantations were at or beyond precommercial thinning age.

Black stain occurred with significantly greater frequency adjacent to roads or major skid trails (2-chain wide strips) than in the main body of plantations ($P < 0.001$). Roadside strips typically had more injured trees and a greater amount of recent soil disturbance than the main body of plantations. Among intensively surveyed stands, there was only one instance of the disease found in the main body of a plantation when it had not been detected in roadside strips or along major skid trails. This is consistent with all other major black stain surveys. Roadside surveys may be used with confidence in the future when assessing incidence and general distribution of black stain on the District.

Black stain occurred with significantly greater frequency ($P = 0.04$) and affected greater numbers of trees ($P = 0.001$) in thinned than unthinned plantations. Furthermore, thinned units tended to have more roads and roads with greater use and higher maintenance standards than unthinned units. It appears that higher disease incidence and greater damage severity in thinned plantations result from site disturbance factors common to that stratum, as well as from the effects of thinning.

Within the range of plantations examined in this survey, plantation age from establishment and aspect did not influence black stain occurrence. There was also no apparent difference in likelihood of infection between crop trees and excess or ingrowth Douglas-fir in established disease centers.

MANAGEMENT RECOMMENDATIONS

We believe that black stain root disease should be a major concern of forest managers on the Medford District since it occurs in approximately one-fifth of the plantations on the District, and can rapidly increase in severity, causing significant damage to young, high value plantations. The current level of incidence is high, although not extremely so; current damage severity is extremely low. The challenge ahead is to maintain damage severity at an acceptably low level using the tools of integrated pest management.

This survey provides data on current incidence and general distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations, and fairly precise figures on damage and loss in a sample of intensively surveyed units. The Glendale, Grants Pass, and Jacksonville Resource Areas should be periodically reevaluated and results compared with those in this report to determine whether severity levels of black stain increase, decrease, or remain the same, and determine the fate of existing disease centers.

At the present time, there is no effective cure for already diseased trees, and genetically resistant host genotypes have not been identified. Current management strategies for control of black stain root disease are either preventative or corrective.

Preventative Management

Black stain root disease is favored by several traditional silvicultural, timber management, and road maintenance activities that are used throughout the range of its hosts. By modifying or eliminating some of these influences and by minimizing site disturbances, tree injuries, and the opportunity for successful insect vectoring, further spread of the pathogen can be reduced.

Minimizing Site Disturbance. Selected timber harvest systems for disease-prone areas should be those that cause the least site disturbance, particularly avoiding soil compaction and soil profile disruption. High lead or skyline yarding are preferable to tractor yarding and should be selected when an option exists. When tractor yarding, the area covered by skid trails should be minimized and yarding should be restricted to the dry season (mid to late summer), when the risk of serious soil compaction is reduced. Skid trails should be designated on the ground prior to the initiation of falling activities, and tree falling should be done to the yarding lead. Soils prone to compaction by heavy equipment even when dry, should not be tractor yarded.

New road construction through established young (< 30 year old) Douglas-fir plantations should be avoided, especially within 1 mile of known black stain disease centers. If new roads must be established or old roads re-opened, remove injured trees and those with root collars

partially covered by fill or side cast from the right-of-way after construction. Damaged and partially buried trees are often weakened and have been shown to be attractive to insect vectors of black stain. Many new infection centers begin in road cut rights-of-way.

Minimizing Tree Injury. During road building and maintenance, and timber harvest activities, avoid creating flooded or poorly drained areas in or around Douglas-fir plantations. Vectors of black stain root disease often visit trees with roots in flooded or poorly drained soils. Avoid using rotary-blade brush cutting machinery to clear roadsides adjacent to Douglas-fir plantations; newly created tree stumps, and trees damaged but not severed by the blades, are attractive to vectors. Special care should also be taken to avoid damaging young plantation trees when falling and yarding sawtimber or moving settings in adjacent stands.

Modifying Silvicultural Practices. Precommercial thinning in Douglas-fir plantations should be done after the vectors of black stain have emerged and established themselves for breeding in other dead, dying, or down materials. Vectors usually emerge in the spring or early summer; precommercial thinning should be scheduled between the last of June and the first of September to ensure that thinning slash will be red and dry by fall. In principle, this will limit opportunities for insect vector population build-up. In areas where summer months are often dry and droughty, the period of precommercial thinning may be extended into late September. When spring and early summer months are cool, wet and overcast, vector emergence may be delayed. In such cases, the timing of precommercial thinning should likewise be adjusted. In some years, thinning windows may be quite compressed; in others, optimal timing will only impose minor limitations.

Corrective Management

Where black stain root disease is already established, a few silvicultural remedies are available. Cultural controls should be incorporated into silvicultural prescriptions at each entry and should not disrupt the normal cutting cycle unless incidence in stands is severe (more than 5 percent of crop trees affected).

When establishing new plantations near areas where black stain is a known management concern, a mix of species should be planted to provide future options for species manipulation. Where black stain is already causing significant mortality in young Douglas-fir stands, resistant or immune tree species should be favored over Douglas-fir in precommercial thinning, especially in active infection centers and in buffer zones immediately adjacent to them. The width of buffer zones should be based on the number of years before the next scheduled entry and a potential pathogen spread rate of 1.5 m/yr. Buffer zones are typically two to three normal tree spacings wide, depending on the tree species, size class, and stocking control guidelines for that species.

When resistant species selections are lacking and precommercial thinning is necessary, avoid thinning in active infection centers and in buffer zones adjacent to them. Thinning in active infection centers should be avoided, since odors from freshly-cut stump surfaces of infected trees are more attractive to vectors than odors from cut surfaces of healthy trees. This leads to increasing disease in crop trees adjacent to active infection centers.

Assistance

Technical assistance in recognizing black stain root disease and developing silvicultural prescriptions to reduce or eliminate losses is readily available from forest pathologists with the USDA Forest Service, Forest Pest Management (FPM), 319 S.W. Pine St., Portland, Oregon 97208; (503) 326-2727 COM 423-2727 FTS.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the fine work of Larry Hutchinson, Jeff Dose, Jim Langhoff, Glenn Calascibetta, Linda Henderson, Kathy Browning, and Cliff Powers. Together, these folks were responsible for the field data collection, the tedious job of recording survey information on field maps and data cards, and the transfer of all this information to permanent maps and records. Included in their combined efforts was nearly 2 months of office pre- and postwork to maximize their efficiency in the field, and our efficiency in the data analysis and report writing. We are very grateful for their high standard of performance and excellent cooperation these last 2-1/2 years. We also wish to express our sincere thanks to Mike Collins for keypunching and editing the raw data and painstakingly transferring all of the survey map information to final figures. Collectively, these folks worked a total of 13 months over a 2-1/2-year period. Many thanks.

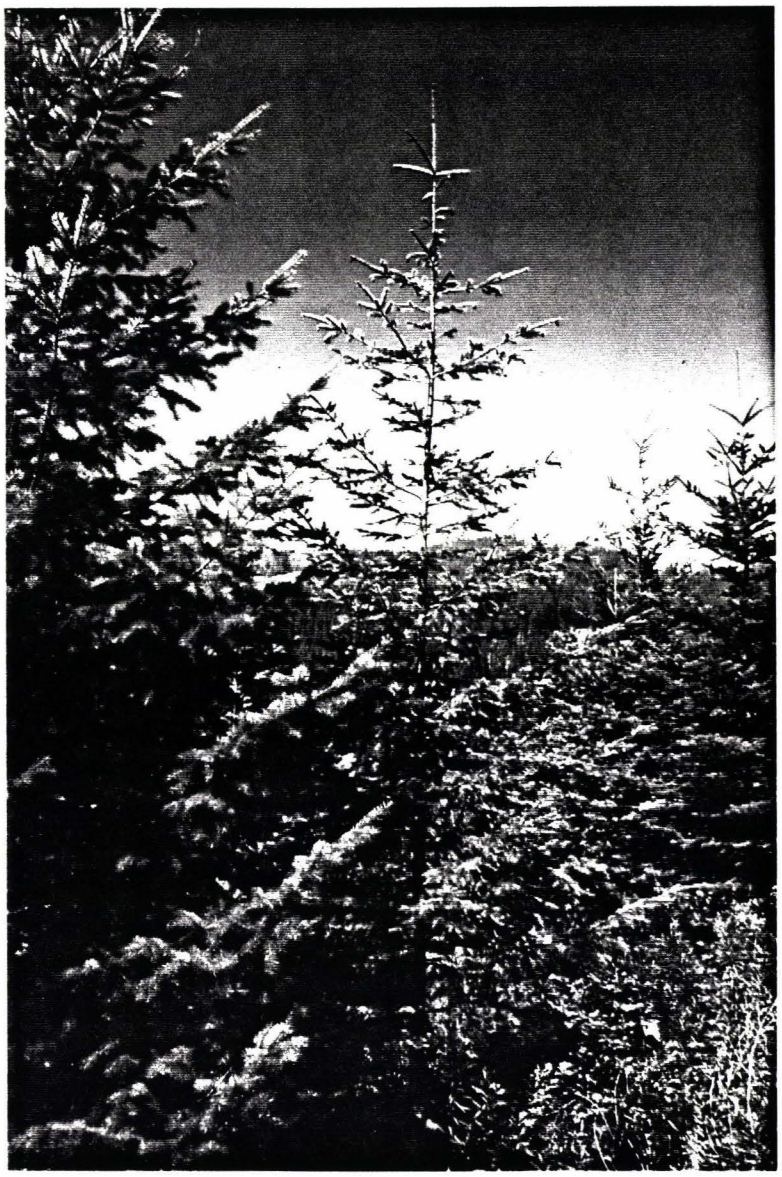


Figure 1. Douglas-fir exhibiting early symptoms of black stain root disease. Note the chlorotic foliage and slight reduction in terminal shoot growth in the current year.

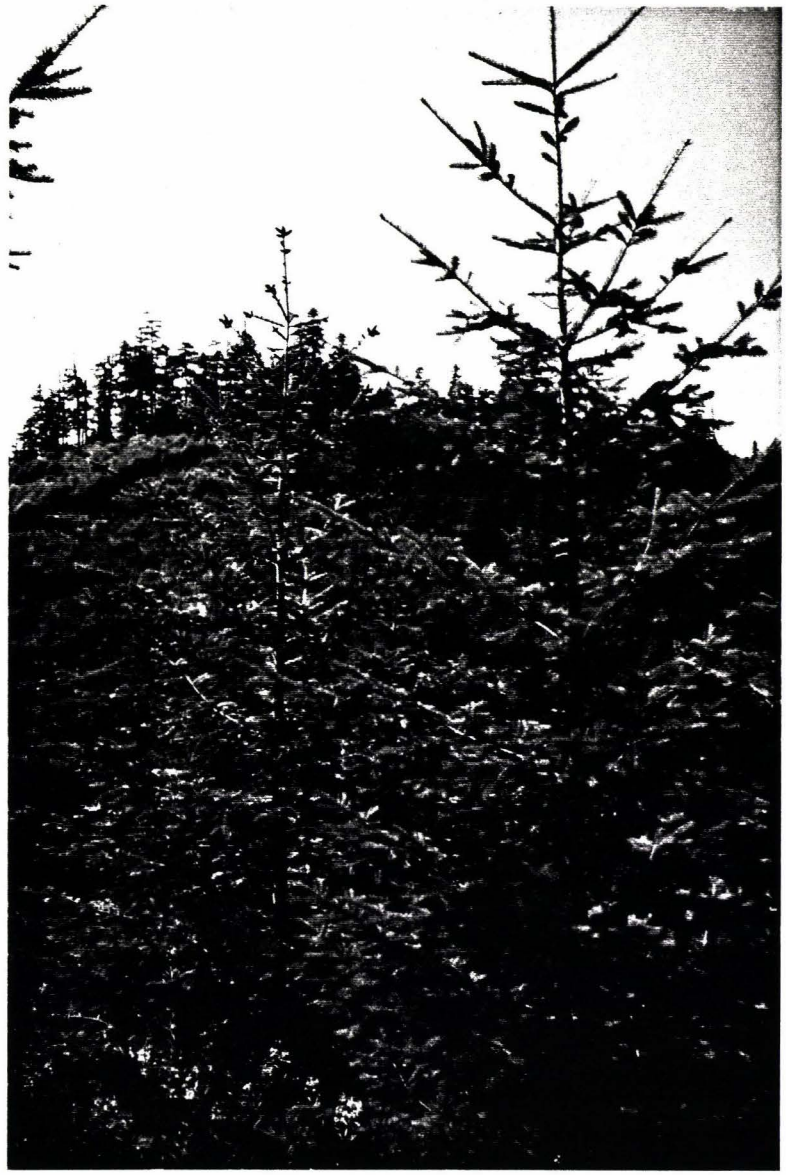


Figure 2. Douglas-fir exhibiting intermediate symptoms of black stain root disease. Note the severe reduction in terminal and lateral growth in the current year, extreme chlorosis, and partial loss of older foliage.

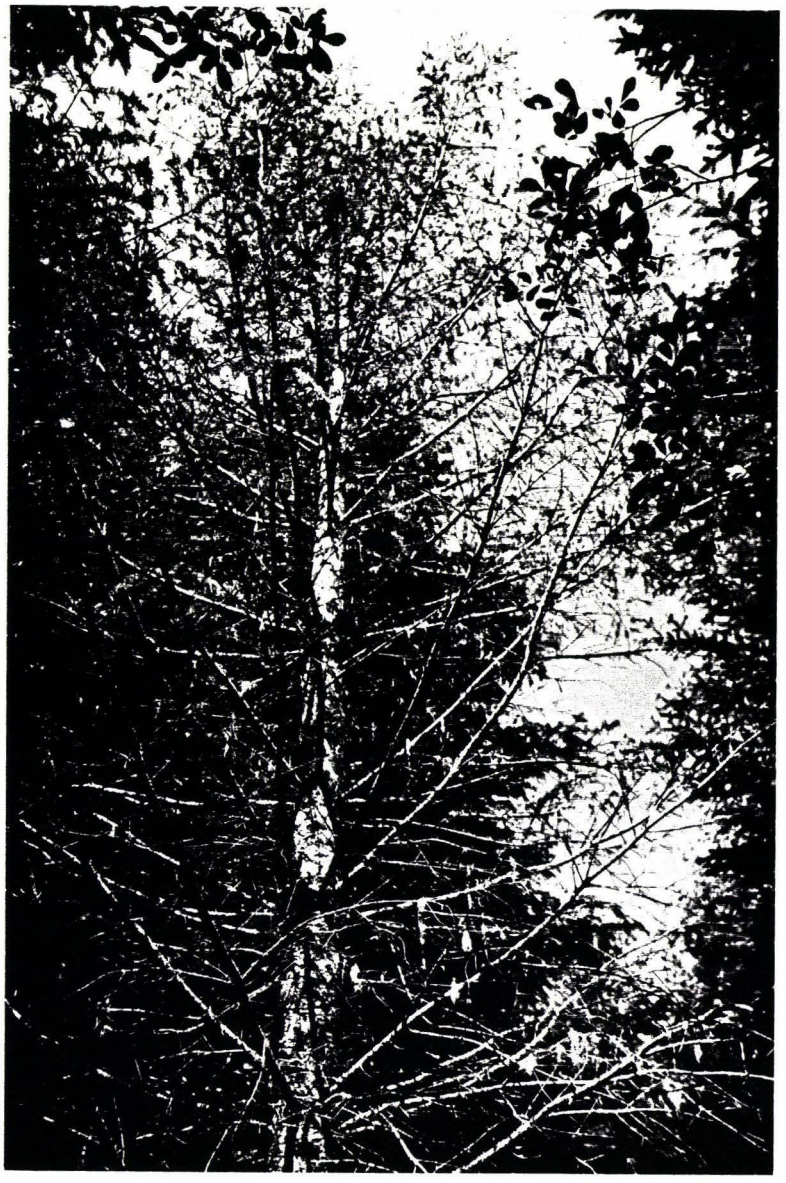


Figure 3. Douglas-fir succumbing to black stain root disease early in the growing season. Note that all of the older foliage has been shed, and the crown is dead. The fungus is still active in the root system for 6-8 more months.

Figure 4. Black stain root disease mortality adjacent to an old skid trail. Oldest mortality without bark and fine branches, and Douglas-fir beetle galleries exposed.

Figure 5. Basal resinosis associated with black stain root disease in the root collar and lower stem of a young sapling Douglas-fir.

Figure 6. Diagnostic evidence of black stain root disease in the lower stem of a young Douglas-fir.

Figure 7. In cross-sectional view, black stain occurs in arcs concentric with the growth rings. Note that the springwood xylem (which conducts water) is more deeply stained than the summerwood xylem (which is nonconductive except in the current year).

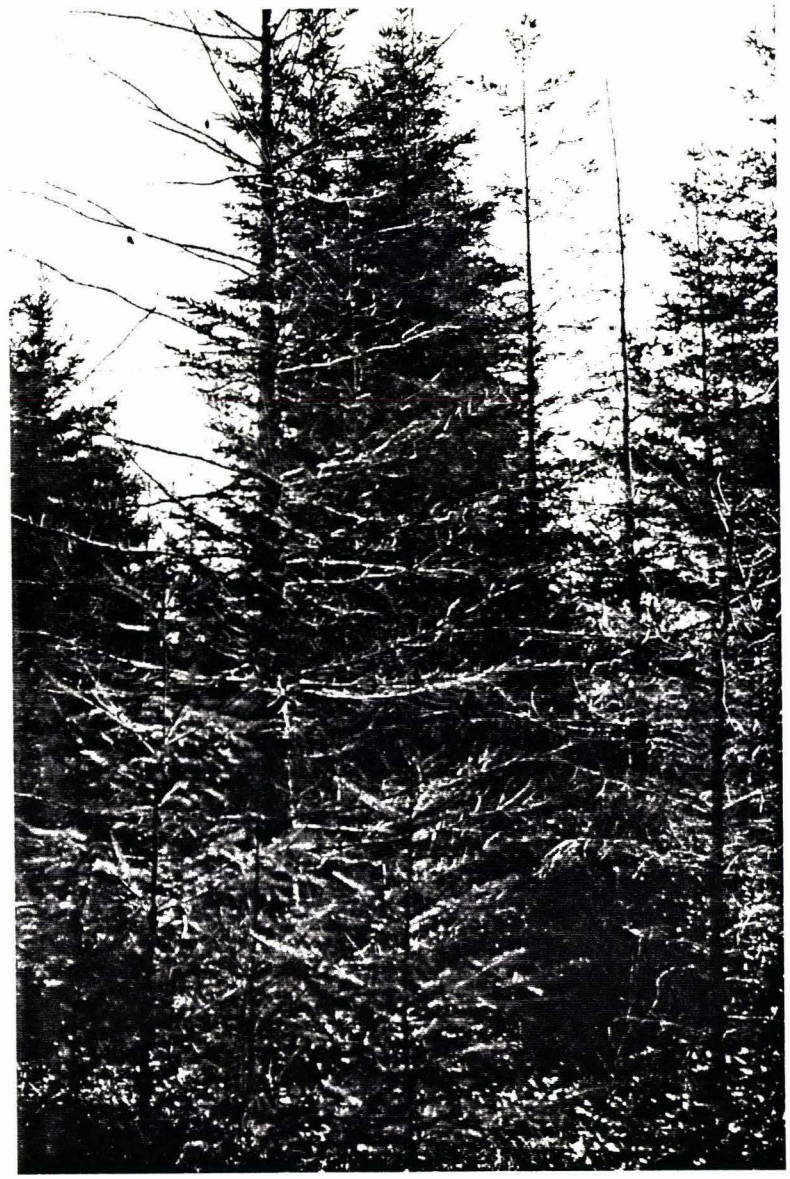


Figure 8. A small black stain root disease center in young Douglas-fir. Dead trees are typically nearer the origin of infection; dying and recently infected trees nearer the actively expanding perimeter.

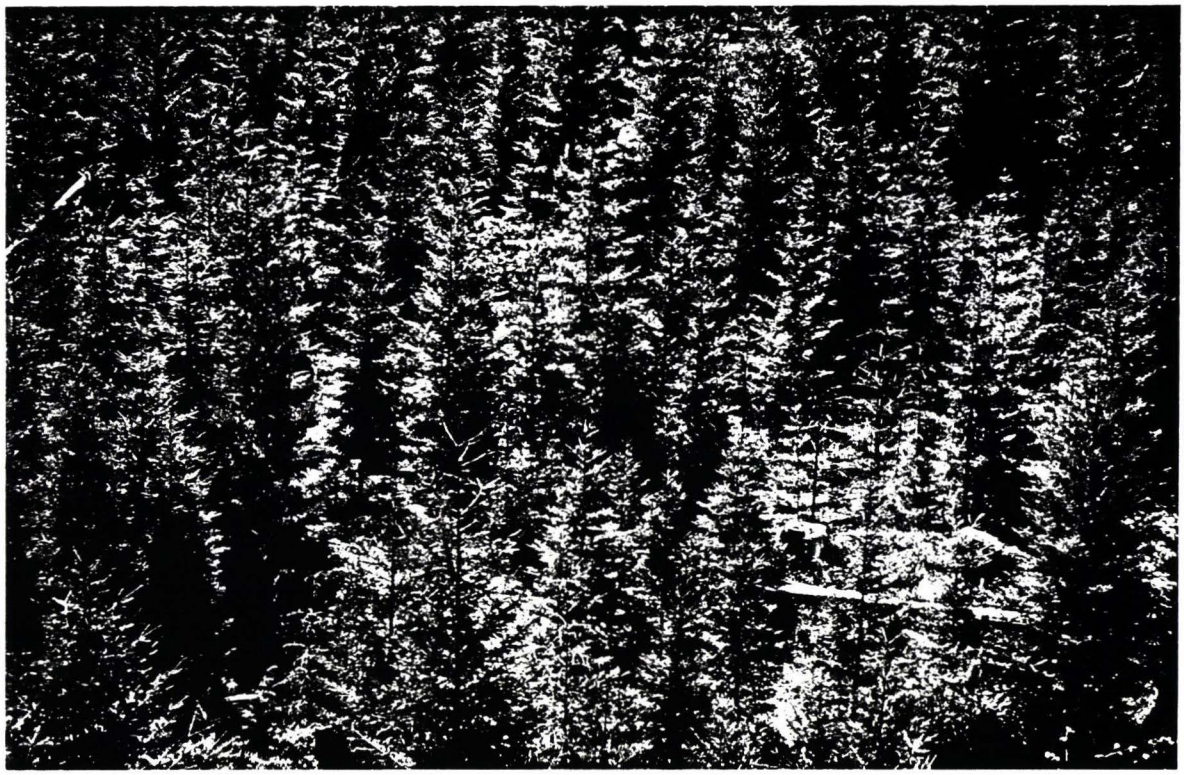


Figure 9. A young Douglas-fir plantation with numerous closely related pockets of disease.

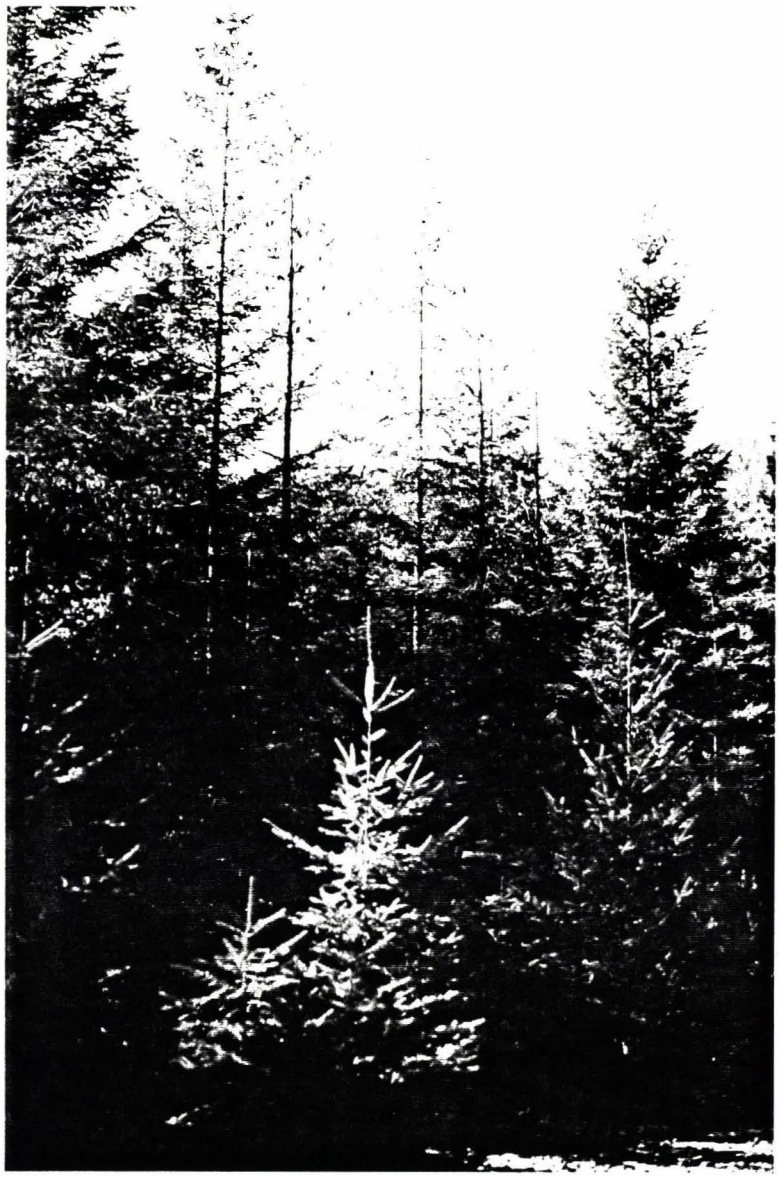


Figure 10. Black stain root disease center in a young Douglas-fir plantation. Note the adjacency of the disease center to a mainhaul road.

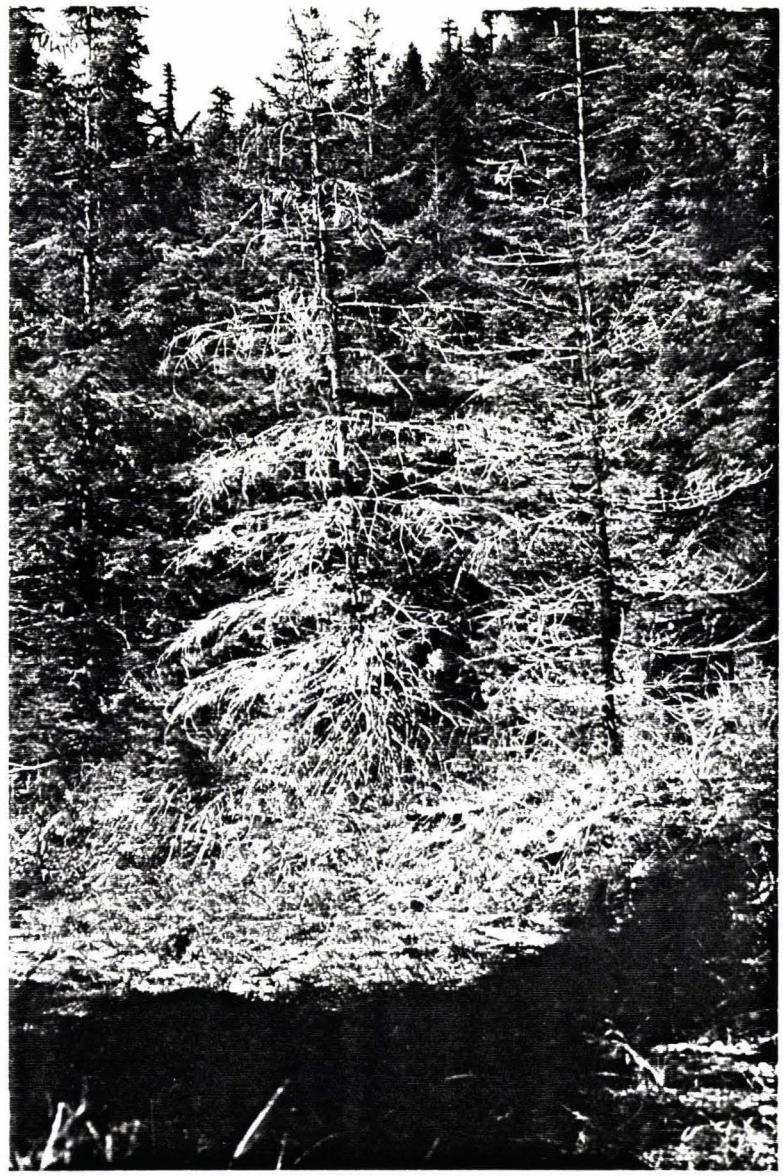


Figure 11. Black stain root disease center in a young Douglas-fir plantation. Note the adjacency of the disease center to a major skid trail.

Figure 12. Black stain root disease center in a young Douglas-fir plantation. Note the adjacency of the disease center to a recent clearcut.

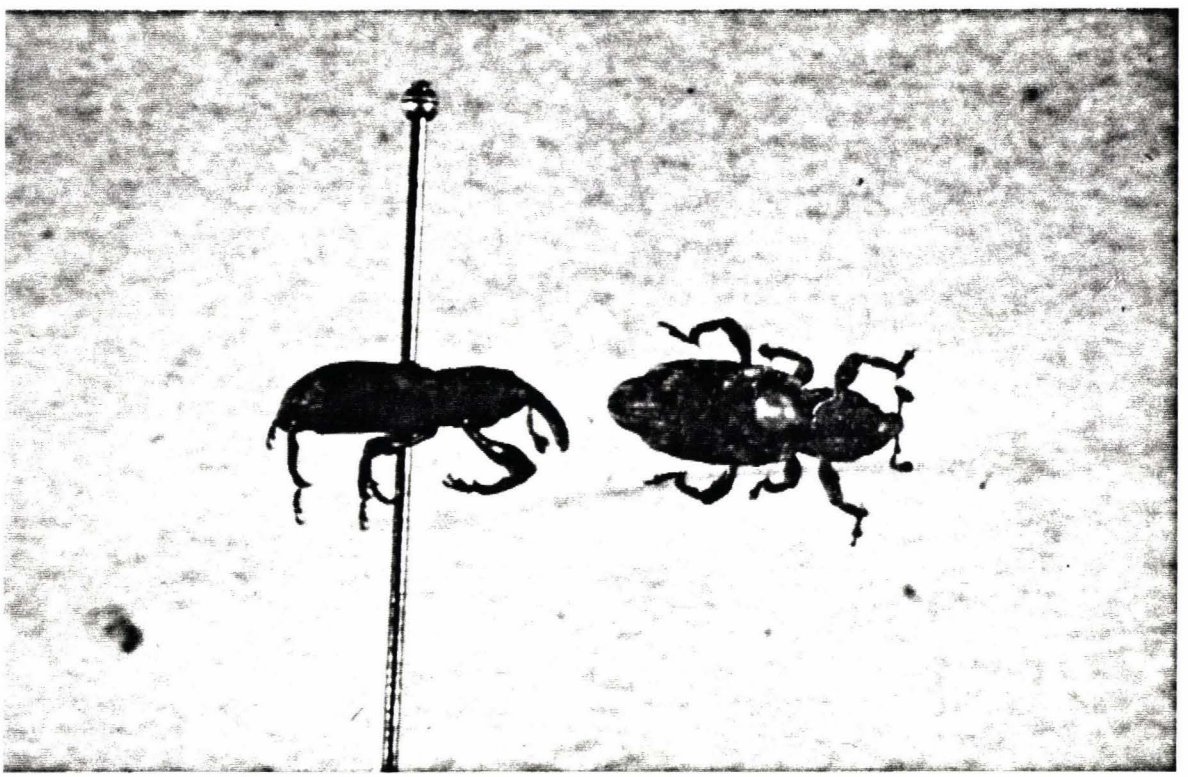


Figure 13. Rogues gallery of insect vectors of black stain root disease in young Douglas-fir. Steremnius carinatus.

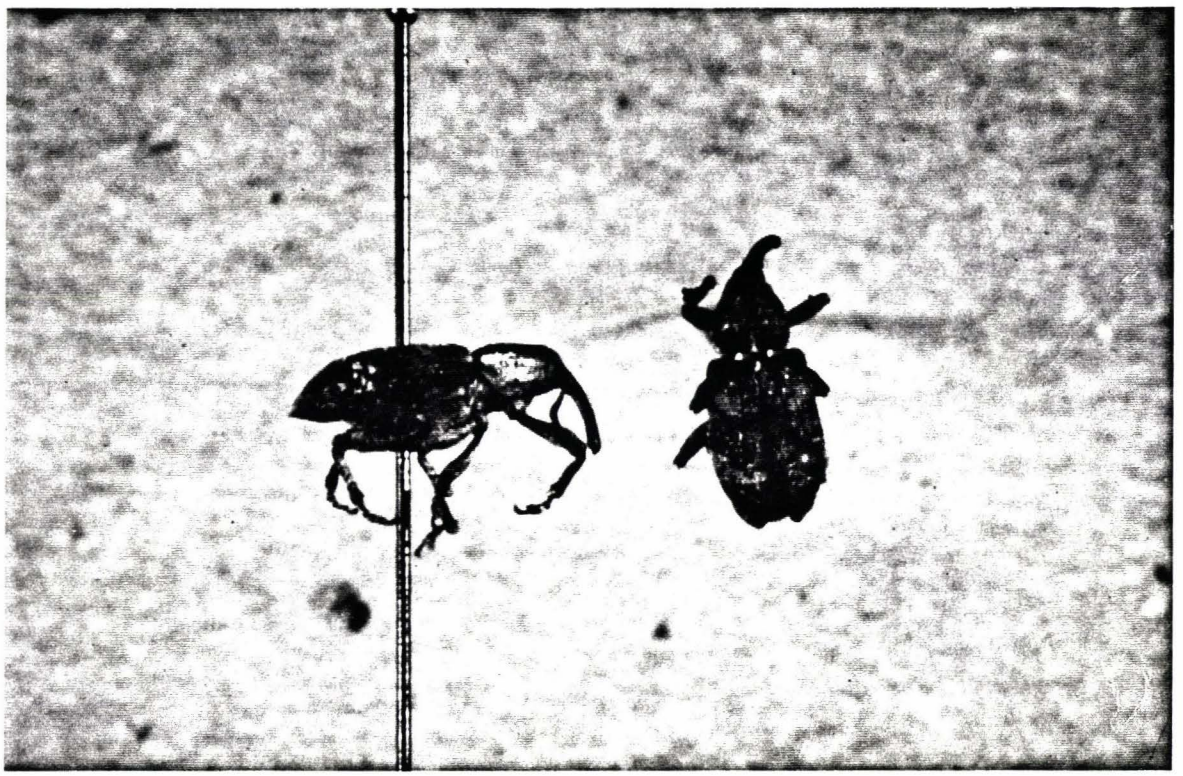


Figure 13 continued. Rogues gallery of insect vectors of black stain root disease in young Douglas-fir. Pissodes fasciatus.

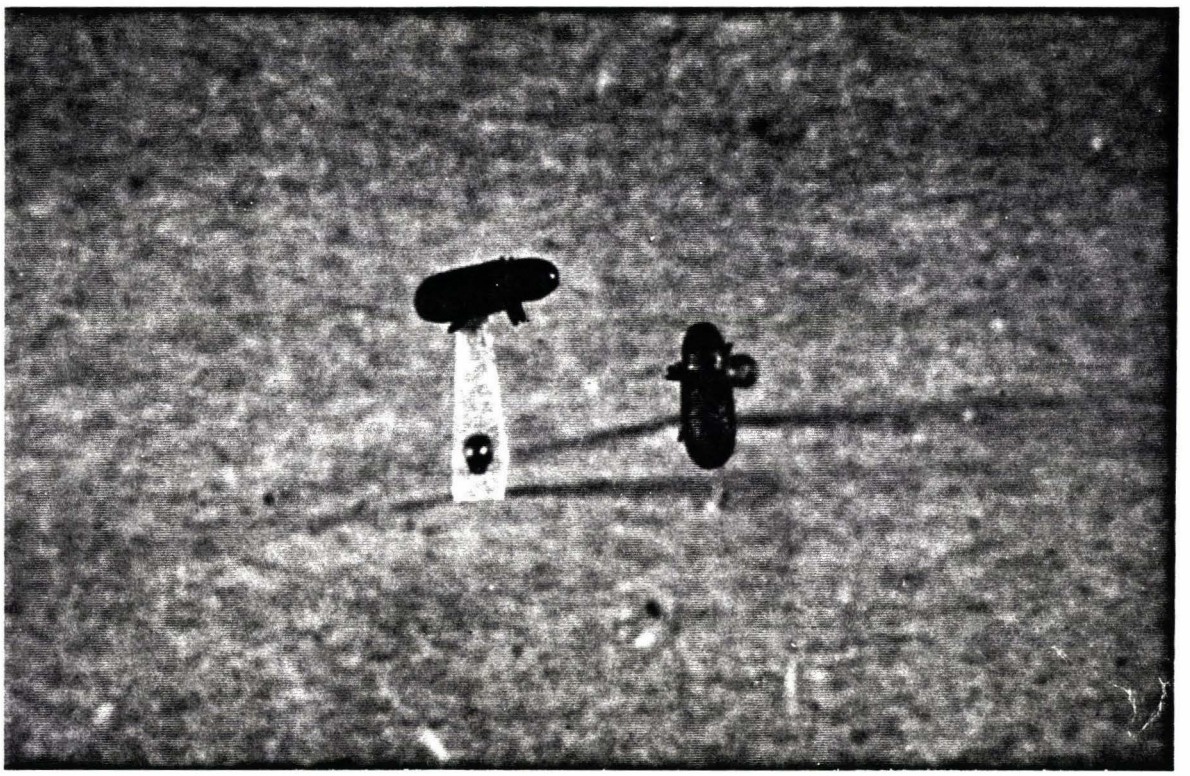
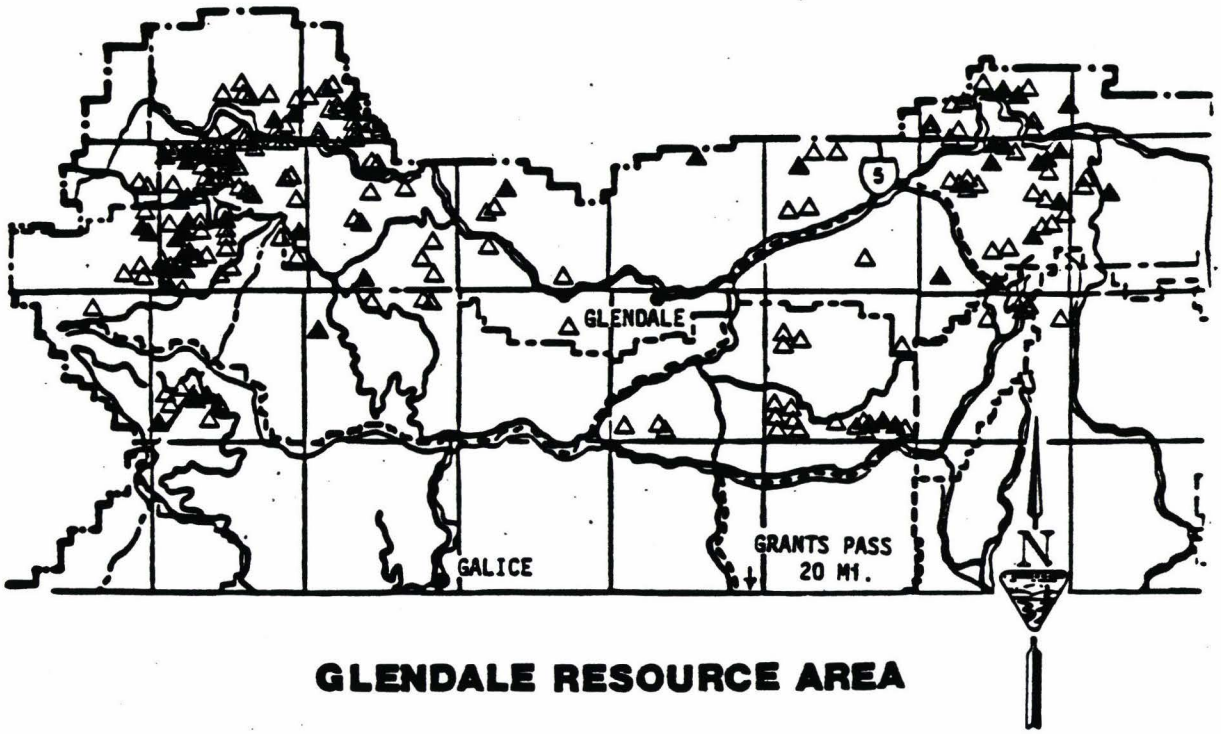


Figure 13 continued. Rogues gallery of insect vectors of black stain root disease in young Douglas-fir. Hylastes nigrinus.

Figure 14. Partially exposed root of a recently infected sapling Douglas-fir. Note the growth of the black stain fungus up the lateral root to the root collar. Onset of obvious crown symptoms commonly coincidental with extensive colonization of the root collar region by the black stain fungus.



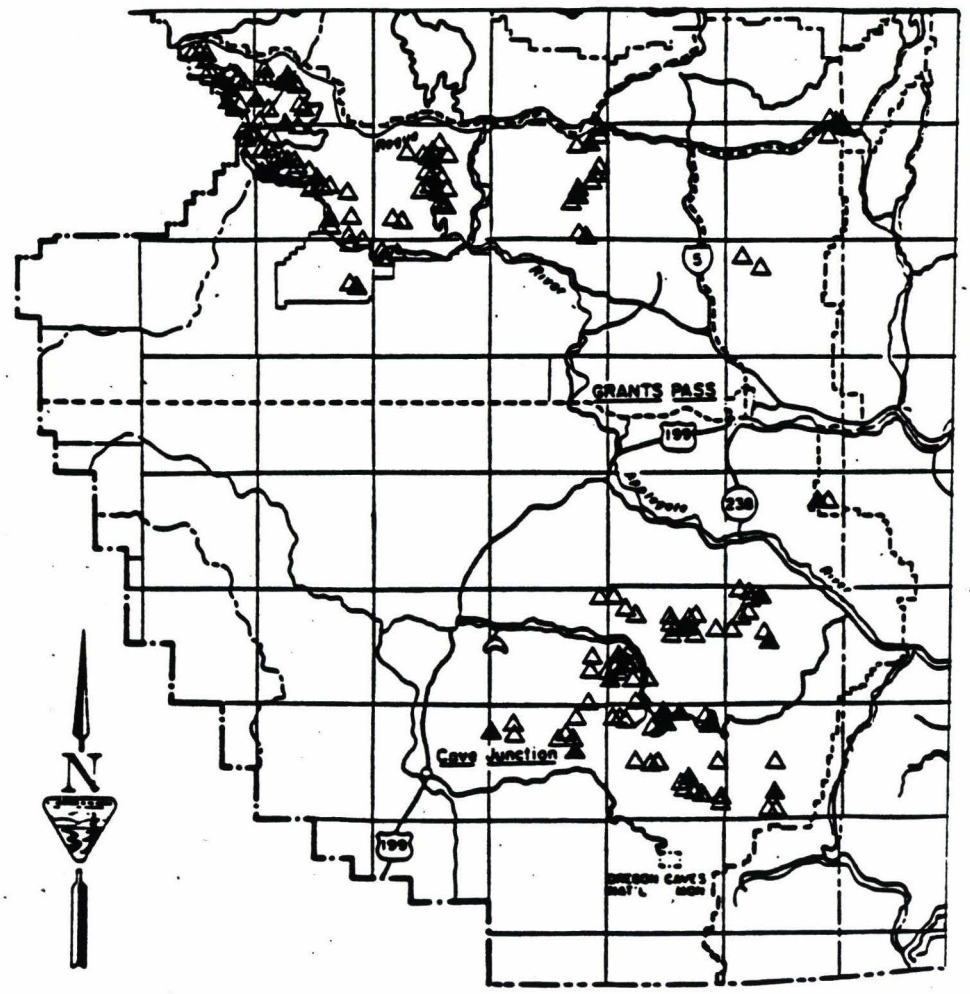
GLENDALE RESOURCE AREA

LEGEND

▲ Plantations with Black Stain Root Disease

△ Plantations without Black Stain Root Disease

Figure 15. Distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations on the Glendale Resource Area, Medford District, BLM; first stage of sampling.



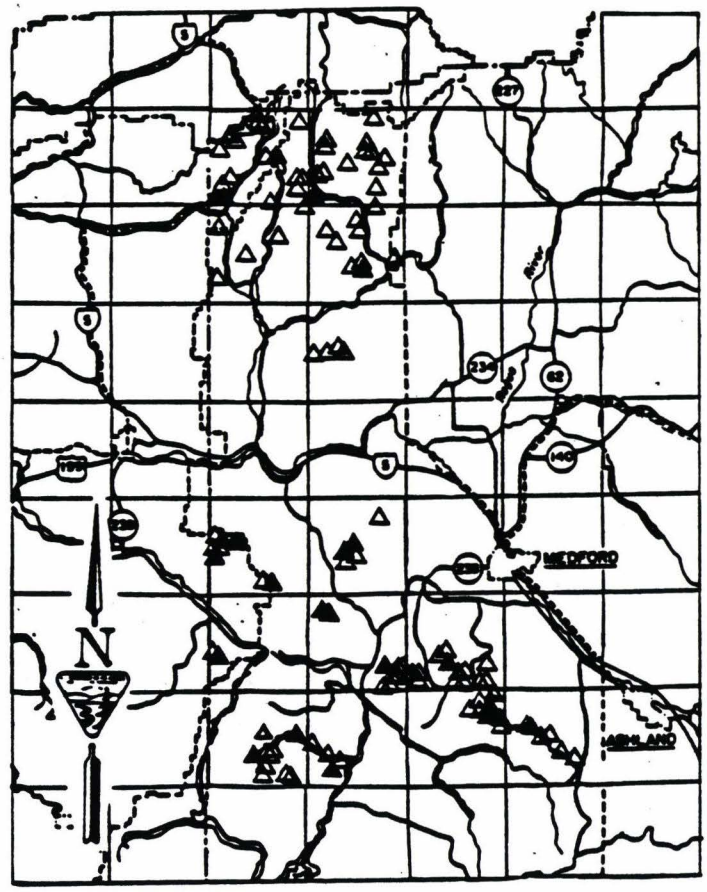
GRANTS PASS RESOURCE AREA

LEGEND

▲ Plantations with Black Stain Root Disease

△ Plantations without Black Stain Root Disease

Figure 16. Distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations on the Grants Pass Resource Area, Medford District, BLM; first stage of sampling.



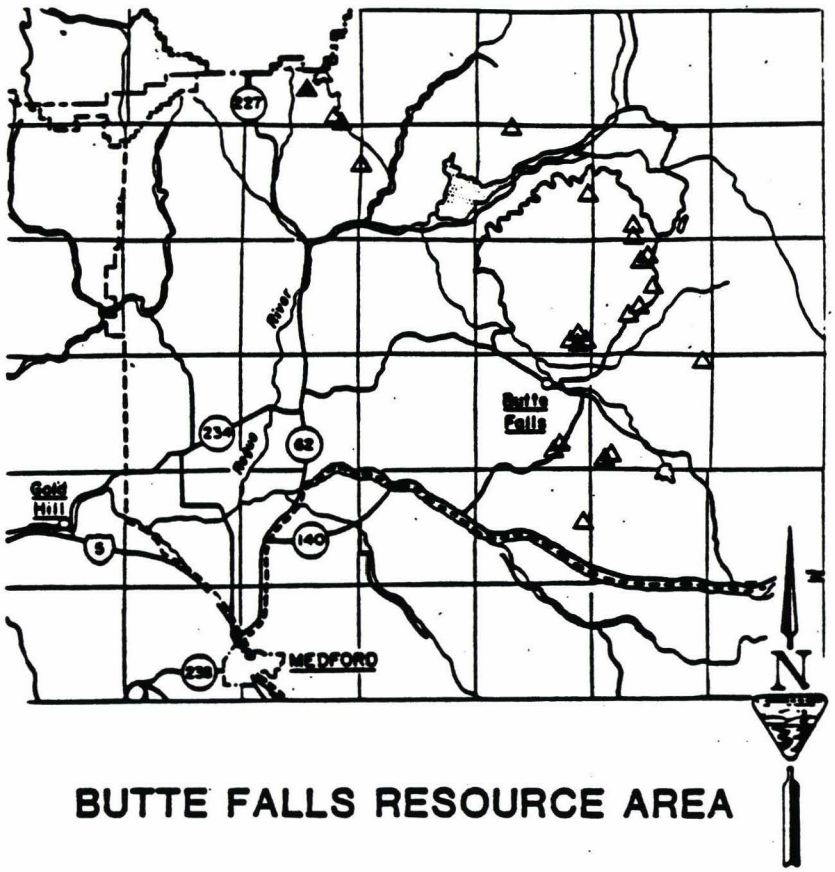
JACKSONVILLE RESOURCE AREA

LEGEND

▲ Plantations with Black Stain Root Disease

△ Plantations without Black Stain Root Disease

Figure 17. Distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations on the Jacksonville Resource Area, Medford District, BLM; first stage of sampling.



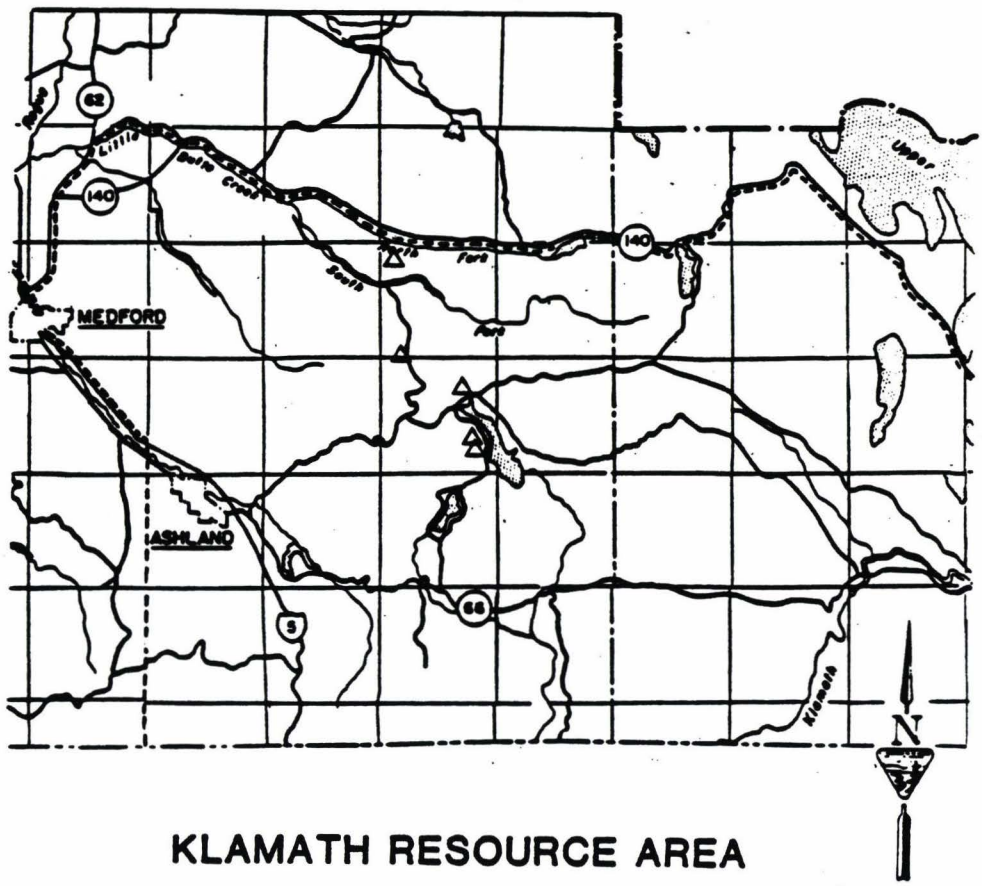
BUTTE FALLS RESOURCE AREA

LEGEND

▲ Plantations with Black Stain Root Disease

△ Plantations without Black Stain Root Disease

Figure 18. Distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations on the Butte Falls Resource Area, Medford District, BLM; first stage of sampling.

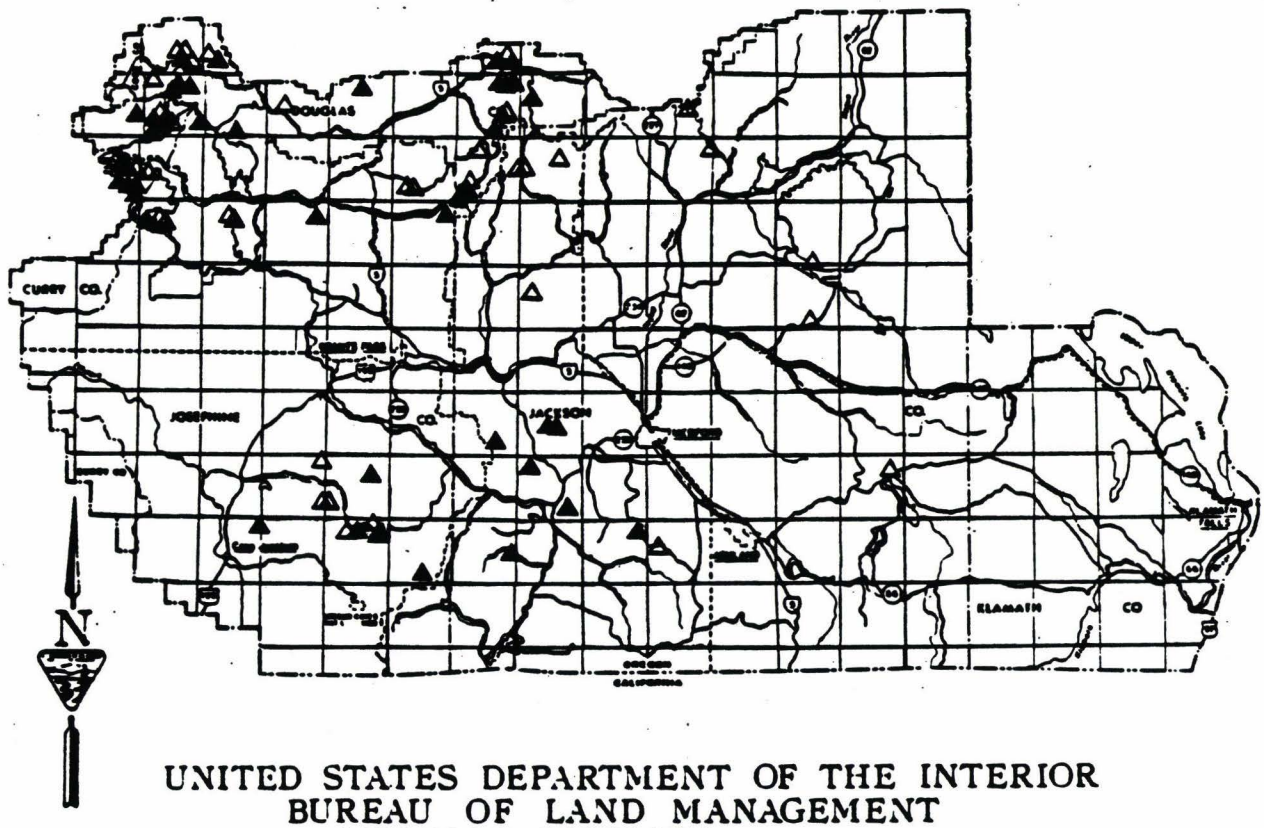


KLAMATH RESOURCE AREA

LEGEND

△ Plantations without Black Stain Root Disease

Figure 19. Distribution of black stain root disease in 10- to 30-year-old Douglas-fir plantations on the Klamath Resource Area, Medford District, BLM; first stage of sampling.



UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
MEDFORD DISTRICT

LEGEND

▲ Plantations with Black Stain Root Disease

△ Plantations without Black Stain Root Disease

Figure 20. Distribution of 80, 10- to 30-year-old Douglas-fir plantations intensively surveyed for black stain root disease on the Medford District, BLM; second stage of sampling.

Table 1. Distribution of all plantations established between 1956 and 1976 on the Medford District, BLM.

Resource Area	Plantations	Percent
Glendale	748	37.8
Grants Pass	563	28.4
Jacksonville	256	12.9
Butte Falls	200	10.1
Klamath	212	10.7
Totals	1,979	100.0

Table 2. Distribution of Douglas-fir plantations established between 1956 and 1976 and surveyed in the extensive survey of black stain root disease on the Medford District, BLM.

Resource Area	Plantations surveyed	Survey %	Occurrence %
Glendale	194	38.8	37.8
Grants Pass	163	32.6	28.4
Jacksonville	114	22.8	13.0
Butte Falls	24	4.8	10.1
Klamath	5	1.0	10.7
Totals	500	100.0	100.0

Table 3. Sample array of Douglas-fir plantations surveyed in the intensive survey of black stain root disease on the Medford District, BLM.

Sample Category	Thinning History	Yarding History	Black stain Detected	Plantations Surveyed
1	PCT +	TR	LEWA +	10
2	PCT +	TR	LEWA -	10
3	PCT +	CBL	LEWA +	10
4	PCT +	CBL	LEWA -	10
5	PCT -	TR	LEWA +	10
6	PCT -	TR	LEWA -	10
7	PCT -	CBL	LEWA +	10
8	PCT -	CBL	LEWA -	10

(PCT +) - Plantation has been precommercially thinned
(PCT -) - Plantation has not been precommercially thinned

(TR) - Previous stand was tractor-yarded
(CBL) - Previous stand was cable-yarded

(LEWA +) - Black stain was detected in the roadside strip(s)
(LEWA -) - Black stain was not detected in the roadside strip(s)

Table 4. Black stain root disease incidence in an extensive survey of 500 randomly selected 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM

Resource Area	Plantations Surveyed	Black Stain Incidence in Plantations											
		All	PCT+	PCT-	TR	CBL	BOTH	PCT+ TR	PCT- TR	PCT+ CBL	PCT- CBL	PCT+ BOTH	PCT- BOTH
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Glendale	194	24.2 s	36.7 s	18.6 s	24.4 ns	23.6 ns	23.1 ns	22.2 ns	25.9 ns	50.0 s	15.4 s	20.0 ns	25.0 ns
Grants Pass	163	16.6 ns	15.6 ns	16.8 ns	25.8 ns	14.8 ns	12.5 ns	25.0 ns	26.1 ns	10.0 ns	15.9 ns	25.0 ns	5.0 ns
Jacksonville	114	15.8 ns	15.6 ns	15.9 ns	20.0 ns	13.5 ns	20.0 ns	0.0 ns	27.3 ns	5.9 ns	15.8 ns	36.4 s	7.1 s
Butte Falls	24	4.2 s	0.0 ns	5.6 ns	0.0 ns	20.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	33.3 ns	0.0 ns	0.0 ns
Klamath	5	0.0 s	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns	0.0 ns
Totals	500	18.6	24.6 s	16.5 ns	19.5 ns	18.4 ns	18.2 ns	17.6 ns	20.3 ns	26.8 s	15.9 s	28.0 s	13.5 s

(PCT+ / PCT-) - Plantation has/has not been precommercially thinned
(TR / CBL) - Previous stand was tractor-/cable-yarded
(BOTH) - Previous stand was both tractor- and cable-yarded

s = significant interaction with incidence of black stain root disease; $P \leq 0.1$, Pearson's Chi-square.
ns = nonsignificant interaction

Table 5. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 1

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	(%)	DF STOCKING W/ BSRD EXCESS (TPA)	(%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT+	TR	LEWA+	20	25	32S	9W	31	004	131217/G051	293	784	0	0	0	0	4	136		MD
			23	22	31S	9W	35	004	130256/G095	415	626	0	0	0	0	4	83		AD
			20	15	32S	9W	29	004	132173/G149	402	360	11	3	0	0	0	36	LW	MD
			25	20	32S	9W	29	005	132173/G151	388	916	0	0	0	0	19	0		
			20	18	32S	6W	3	002	130648/G178	203	578	0	0	0	0	3	17		MD
			18	30	38S	3W	7	001	151127/J394	166	288	3	2	7	2	112	144	LW PW	MD
			21	28	39S	2W	1	008	151460/J412	361	649	0	0	0	0	0	52		MD
			22	99	33S	4W	31	006	152228/J434	227	712	0	0	0	0	26	176		AD MD
			17	24	33S	10W	26	003	10164/P224	395	2013	0	0	0	0	32	176		MD
			28	41	39S	6W	12	003	13458/P303	170	120	0	0	0	0	50	6		AD
									MEAN -	302	705	1	0	1	0	25	82		
SAMPLE STATISTICS									SE -	32	164	1	0	1	0	11	22		
									LCL -	270	541	0	0	0	0	14	60		
									UCL -	334	869	3	1	1	0	36	105		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.

TR / CBL : previous stand was tractor-/cable-yarded, respectively.

LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.

PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)

AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.

LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 2

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	(%)	DF STOCKING W/ BSRD EXCESS (TPA)	(%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT+	TR	LEWA-	16	9	35S	2E	35	003	162067/B497	86	138	0	0	0	0	57	179		AD MD
			15	11	33S	5W	31	018	132133/G003	273	269	0	0	0	0	22	57		MD
			22	39	31S	4W	27	001	130061/G016	249	341	0	0	0	0	3	6	PW	AD
			23	93	31S	8W	19	009	130124/G102	149	244	0	0	0	0	118	71		MD
			20	27	32S	9W	20	002	131118/G144	489	972	0	0	0	0	11	6		MD
			20	25	32S	9W	20	005	131121/G150	315	537	0	0	0	0	5	232		AD MD
			16	12	33S	4W	29	007	152224/J385	179	267	0	0	0	0	42	203		MD
			15	14	33S	10W	25	002	10148/P218	332	606	0	0	0	0	0	141		MD
			18	26	33S	10W	23	006	12660/P220	390	793	0	0	0	0	23	32		MD
			16	5	33S	10W	23	201	12664/P221	220	715	0	0	0	0	0	0		AD MD
									MEAN -	268	488	0	0	0	0	28	93		
SAMPLE STATISTICS									SE -	38	88	0	0	0	0	12	28		
									LCL -	231	400	0	0	0	0	16	65		
									UCL -	306	576	0	0	0	0	40	121		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 3

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	DF STOCKING W/ BSRD CROP (%)	DF STOCKING W/ BSRD EXCESS (TPA)	DF STOCKING W/ BSRD EXCESS (%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT+	CBL	LEWA+	22	79	31S	4W	27	004	130064/G015	218	613	0	0	0	0	61	10		MD
			20	15	32S	4W	3	003	130314/G023	246	1075	0	0	0	0	4	11		AD
			18	11	32S	4W	1	009	131836/G029	252	121	26	10	0	0	0	0	LW	AD MD
			23	33	32S	4W	1	006	131836/G030	280	255	0	0	0	0	0	0		AD
			20	26	32S	10W	24	002	131314/G089	228	2125	0	0	0	0	0	0		AD
			23	14	32S	9W	5	007	131792/G158	298	598	10	3	52	9	0	0	LW	AD MD
			21	22	32S	9W	9	004	132053/G166	288	259	0	0	0	0	0	5		AD
			16	21	37S	3W	21	001	150869/J453	140	264	0	0	0	0	33	14		MD
			19	11	34S	7W	11	001	12744/P198	145	145	0	0	0	0	25	0		MD
			16	15	33S	10W	23	007	12661/P223	339	696	0	0	0	0	0	43		AD MD
									MEAN -	243	615	4	1	5	1	12	8		
									SE -	20	193	3	1	5	1	7	4		
									LCL -	223	422	1	0	0	0	6	4		
									UCL -	264	808	6	2	10	2	19	13		

SAMPLE STATISTICS

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD).
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 4

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	(%)	DF STOCKING W/ BSRD EXCESS (TPA)	(%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT+	CBL	LEWA-	29	15	32S	1W	23	105	161717/B479	128	189	0	0	0	0	41	66		AD
			22	16	31S	4W	23	005	130033/G017	304	742	0	0	0	0	58	4		MD
			22	14	32S	7W	17	007	130714/G076	139	374	0	0	0	0	4	7		MD
			23	30	31S	9W	35	002	130254/G100	334	816	0	0	0	0	0	33		AD
			14	15	31S	9W	23	010	130198/G107	174	347	0	0	0	0	39	56		MD
			21	38	33S	3W	15	006	152312/J443	171	236	0	0	0	0	32	38		AD MD
			19	34	37S	3W	21	003	150871/J450	180	267	4	2	0	0	18	43	LW	MD
			10	16	34S	8W	10	900	12831/P252	385	62	0	0	0	0	0	5		AD MD
			22	37	34S	8W	10	014	12829/P254	132	66	0	0	0	0	58	10		
			21	29	39S	6W	9	006	11901/P336	363	416	0	0	0	0	65	0		
									MEAN -	231	351	0	0	0	0	32	26		
S A M P L E S T A T I S T I C S									SE -	33	81	0	0	0	0	8	8		
									LCL -	198	271	0	0	0	0	24	18		
									UCL -	264	432	1	0	0	0	40	34		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 5

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	DF STOCKING W/ BSRD CROP (%)	DF STOCKING W/ BSRD EXCESS (TPA)	DF STOCKING W/ BSRD EXCESS (%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT-	TR	LEWA+	21	15	32S	4W	23	007	130429/G033	220	701	0	0	0	0	34	190		MD
			21	37	32S	8W	33	005	131162/G055	280	926	0	0	0	0	7	6		AD MD
			21	28	32S	9W	4	006	131807/G074	279	1540	0	0	0	0	10	0		MD
			30	24	32S	3W	17	002	130281/G187	218	399	0	0	0	0	7	43		AD MD
			26	85	33S	4W	31	003	152227/J435	91	164	0	0	0	0	73	159		
			23	54	33S	3W	31	003	150278/J441	172	397	0	0	0	0	261	50		
			24	14	34S	9W	18	007	12966/P239	200	416	0	0	0	0	73	162		AD MD
			21	26	39S	8W	1	007	13566/P318	384	574	0	0	0	0	16	65		AD
			24	27	39S	6W	3	009	13430/P334	287	435	0	0	0	0	164	191		MD
			29	52	39S	5W	27	102	13401/P339	152	624	0	0	0	0	57	586		MD
									MEAN -	228	618	0	0	0	0	70	145		
S A M P L E S T A T I S T I C S									SE -	26	122	0	0	0	0	26	54		
									LCL -	202	496	0	0	0	0	44	91		
									UCL -	255	739	0	0	0	0	96	199		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 6

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	(%)	DF STOCKING W/ BSRD EXCESS (TPA)	(%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT-	TR	LEWA-	13	8	34S	2E	35	014	161810/B494	211	17	0	0	0	0	644	0		AD MD
			16	32	32S	9W	29	006	132175/G162	300	1073	0	0	0	0	6	108		AD MD
			18	48	31S	9W	27	003	130222/G171	130	221	0	0	0	0	13	115		AD
			30	30	32S	4W	24	004	130519/G186	118	123	0	0	0	0	60	120		MD
			21	32	33S	4W	3	014	152198/J376	162	244	0	0	0	0	21	63		
			23	30	33S	4W	25	001	150332/J383	136	186	0	0	0	0	148	0		
			19	8	38S	3W	36	002	151259/J397	180	259	0	0	0	0	46	51		
			20	30	38S	3E	11	001	122372/K472	98	0	0	0	0	0	154	0		AD
			17	34	38S	7W	1	004	13293/P295	277	523	0	0	0	0	16	32		
			27	43	39S	6W	1	002	13418/P302	176	395	0	0	0	0	98	243		MD
									MEAN -	179	304	0	0	0	0	121	73		
SAMPLE STATISTICS									SE -	21	99	0	0	0	0	61	24		
									LCL -	158	205	0	0	0	0	60	49		
									UCL -	200	403	0	0	0	0	181	97		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.

TR / CBL : previous stand was tractor-/cable-yarded, respectively.

LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.

PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)

AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.

LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 7

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	DF STOCKING W/ BSRD CROP (%)	DF STOCKING W/ BSRD EXCESS (TPA)	DF STOCKING W/ BSRD EXCESS (%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT-	CBL	LEWA+	15	10	33S	9W	31	004	12626/G085	215	395	0	0	0	0	0	0		
			22	27	31S	8W	29	007	131746/G117	238	876	0	0	0	0	17	118		AD MD
			23	47	32S	8W	33	005	130918/G153	206	822	0	0	0	0	41	103		MD
			30	42	32S	4W	34	005	130441/G185	183	554	0	0	0	0	32	103		AD MD
			20	22	37S	4W	27	008	152630/J391	137	183	0	0	0	0	25	46		
			21	15	38S	3W	25	003	152704/J398	254	424	0	0	0	0	0	0		AD MD
			26	83	34S	5W	1	013	12682/P205	152	182	0	0	0	0	101	85		AD
			20	10	33S	10W	25	008	12673/P225	327	1751	0	0	0	0	12	18		MD
			24	28	34S	9W	8	006	12887/P271	192	517	0	0	0	0	13	0		AD
			22	37	38S	6W	14	013	13254/P345	203	651	0	0	2	0	26	68	LW PW	AD MD
									MEAN -	211	636	0	0	0	0	27	54		
SAMPLE STATISTICS									SE -	17	144	0	0	0	0	9	15		
									LCL -	194	491	0	0	0	0	17	39		
									UCL -	228	780	0	0	0	0	36	69		

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

Table 5 continued. Black stain root disease damage survey in an intensive subsample of eighty (80) randomly selected, 10- to 30-year-old Douglas-fir plantations on the Medford District, BLM.

SAMPLE CATEGORY - 8

THIN HIST	YARD HIST	BSRD ROAD	PLANTATION AGE	PLANTATION AC	LEGAL DESC. T.	R.	SEC.	UNIT NO.	SITE NO.	DF STOCKING CROP (TPA)	DF STOCKING EXCESS (TPA)	DF STOCKING W/ BSRD CROP (TPA)	DF STOCKING W/ BSRD CROP (%)	DF STOCKING W/ BSRD EXCESS (TPA)	DF STOCKING W/ BSRD EXCESS (%)	OTHER STOCKING CROP (TPA)	OTHER STOCKING EXCESS (TPA)	ROOT DISEASE	OTHER DAMAGE
PCT-	CBL	LEWA-	23	18	33S	1E	7	103	161935/B481	70	170	0	0	0	0	26	178		
			18	15	39S	9W	19	005	12590/G081	196	419	0	0	0	0	0	0		AD
			15	14	32S	9W	6	006	131979/G088	225	767	0	0	0	0	0	12		AD
			17	7	33S	5W	31	006	131323/G192	196	479	0	0	0	0	13	0		AD MD
			13	14	32S	3W	17	008	152555/J403	105	150	0	0	0	0	12	92		AD MD
			20	30	33S	3W	19	005	152325/J439	209	343	0	0	0	0	104	67		
			21	14	39S	1W	17	005	151364/J459	325	470	0	0	0	0	10	45		
			24	23	34S	9W	17	003	12946/P264	91	61	0	0	0	0	14	25		
			18	27	38S	6W	30	005	13280/P287	406	648	0	0	0	0	0	0		AD MD
			18	30	38S	7W	25	002	13328/P288	363	477	0	0	0	0	0	0		AD MD
									MEAN -	218	398	0	0	0	0	18	42		
									SE -	36	71	0	0	0	0	10	18		
									LCL -	182	328	0	0	0	0	8	24		
									UCL -	255	469	0	0	0	0	28	60		

SAMPLE STATISTICS

PCT+ / PCT- : plantation has/has not been precommercially thinned, respectively.
TR / CBL : previous stand was tractor-/cable-yarded, respectively.
LEWA+ / LEWA- : black stain was/was not found in the roadside (extensive) survey, respectively.
PW : Phellinus weirii - cause of laminated root rot; LW : Leptographium wageneri - cause of black stain root disease (BSRD)
AD : Animal Damage detected in plantation crop trees; MD : Mechanical Damage detected on crop trees.
LCL / UCL : Mean minus SE / Mean plus SE, respectively. Confidence limits (LCL/UCL) rounded to nearest whole integer.

SELECTED REFERENCES

Goheen, D. J., and E. M. Hansen. 1978. Black stain root disease in Oregon and Washington. Plant Dis. Rep. 62:1098-1102.

Hansen, E. M. 1978. Incidence of Verticicladiella wageneri and Phellinus weirii in Douglas-fir adjacent to and away from roads in western Oregon. Plant Dis. Rep. 62:179-181.

Hansen, E. M., D. J. Goheen, P. F. Hessburg, J. J. Witcosky, and T. D. Schowalter. 1988. Biology and management of black stain root disease in Douglas-fir, pp. 63-80. In: Leptographium Root Diseases of Conifers. T. C. Harrington and F. W. Cobb, Jr., eds. APS Press.

Harrington, T. C. 1988. Leptographium species, their distributions, hosts, and insect vectors, pp. 1-40. In: Leptographium Root Diseases on Conifers. T. C. Harrington and F. W. Cobb, Jr., eds. APS Press.

Harrington, T. C., F. W. Cobb, Jr., and J. W. Lowensbery. 1985. Activity of Hylastes nigrinus, a vector of Verticicladiella wageneri, in thinned stands of Douglas-fir. Can. J. For. Res. 15:519-523.

Harrington, T. C., C. Reinhart, D. A. Thornburgh, and F. W. Cobb, Jr. 1983. Association of black-stain root disease with precommercial thinning of Douglas-fir. For. Sci. 29:12-14.

Hessburg, P. F., and E. M. Hansen. 1986. Soil temperature and rate of colonization of Ceratocystis wageneri in Douglas-fir. Phytopathology 76:627-631.

Hessburg, P. F., and E. M. Hansen. 1986. Mechanisms of intertree transmission of Verticicladiella wageneri in young Douglas-fir. Can. J. For. Res. 16:1250-1254.

Hessburg, P. F., and E. M. Hansen. 1987. Pathological anatomy of black stain root disease on Douglas-fir. Can. J. Bot. 65:962-971.

Hicks, B. R., F. W. Cobb, Jr., and P. Gersper. 1980. Isolation of Ceratocystis wageneri from forest soil with a selective medium. Phytopathology 70:880-883.

Witcosky, J. J., and E. M. Hansen. 1985. Root-colonizing insects recovered from Douglas-fir in various stages of decline due to black stain root disease. Phytopathology. 75:399-402.

Witcosky, J. J., T. D. Schowalter, and E. M. Hansen. 1986. Influence of time of precommercial thinning on the colonization of Douglas-fir by three species of root-colonizing insects. Can. J. For. Res. 16:745-749.

Witcosky, J. J., T. D. Schowalter, and E. M. Hansen. 1986. Hylastes nigrinus, (Coleoptera: Scolytidae), Pissodes fasciatus, and Steremnius carinatus (Coleoptera: Curculionidae) as vectors of black stain root disease of Douglas-fir. Environ. Entomol. 15:1090-1095.